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Thursday, September 24, 2009

Staving off the Cosmic Malthus

Robin Hanson has a good argument about the inevitability of Malthusian economics in our future -- here refined by Anders Sandberg. This Malthusian future is distant in human terms but an eyeblink in cosmic terms. Sandberg observes that that our cosmic environment, while very large, is finite and dispersed. Emigration beyond our solar system can expand these resources only polynomially, which can't keep up with exponential economic or population growth. Therefore, our current boom era of exponential economic growth, wherein manufacturing productivity has grown at about the same positive percentage rate per year starting in Western Europe in the late Middle Ages, is historically very unique and must eventually come to an end. Furthermore, Hanson argues that the specter of Malthus, purged in the late 20th century by declining fertility, will return -- Darwinian genetic adaptation to modern fertility-reducing conditions and technologies will eventually bring population growth rates back to exponentially positive rates until once again resource limits are reached and most humans (or posthumans) live at subsistence levels -- very extreme poverty by the standards of modern developed countries.

The Darwinian argument may be overcome if culture keeps evolving faster than genes and thereby can keep overcoming future genetic adaptations. (Richard Dawkins argues that we can overcome our selfish genes). It may be rebutted that units of culture (what Dawkins calls "memes") themselves are Darwinian competitors and thus also face Malthusian limits, or that future computerized minds may reproduce very quickly and evolve as fast as culture. I won't elaborate on these arguments further here as Robin has got me into a hyper-futuristic mood and I'd like to suggest another way in which we might achieve more "room at the bottom".

Hanson counts atoms in order to estimate the density of information (or of minds) that might be created. But, just as Freeman Dyson, Gerard O'Neill, and others showed that planets are a waste of mass, so that technologically mature civilizations won't have planets, I'll argue here that atoms are a waste of mass-energy, and technologically mature civilizations may not have very many of them. Instead information may be stored in photons and collections of electrons and positrons (for example geonium) may handle most information processing and form the substrate of minds.

Given that a photon can come in a vast number of possibly distinguishable frequencies, the spectrum spanning more than 20 orders of magnitude, we may be able to store at least 10^30 bits per photon. One approach to creating photons is to simply capture the energy of solar nuclear fusions as photons, as we already know how to do -- this should give us about 10^95 bits worth of photons of average energy blue. But we'd have to either wait billions of years for all these fusion reactions to occur naturally in the sun or accelerate them somehow. More completely, the neutrons and protons in the sun, if converted into photons of average energy blue, would give us 10^97 bits and we may not have to wait billions of years if we can figure out how to bring about this hypothetical conversion. This is a fascinating but very speculative bit of physics which I will explore further.

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Of course, we will still need some electrons or positrons around to actually process that information and recycle photons. And we still need some neutrons and protons around to fuse for energy to make up for the waste heat, to the extent that geonium computations will be less than perfectly reversible. Unless we are very clever and figure out how to make solid structures that don't blow up out of electrons and positrons, we will need some magnetic tanks made out of traditional heavy atoms to hold the geonium. Worse, the strong tendency for baryon number to be conserved makes cracking protons difficult and perhaps impossible. Protons are made out of three quarks, and while cracking quarks is quite possible (particles with two quarks but zero net baryon number decay spontaneously into particles with no quarks), the tendency for baryon numbers to be conserved at the energy levels used by current particle accelerators suggests that cracking the proton, if we can even figure out how to do it, may require vast amounts of energy, so that only a tiny fraction of the sun's neutrons and protons might be converted before we run out of energy from the fusion of the remaining nuclei. Right now we know how to crack the neutron into a proton and electron, but we don't know how to crack the proton. To be feasible we will have to discover a way to "catalyze" proton decay, by analogy to how the activation energies of chemical reactions can be lowered by catalysts.

If feasible, converting wasteful atoms into more useful photons would give us many orders of magnitude more room at the bottom. Staving off Malthus then becomes a question of how much information can be stored in a photon, and of how quickly electrons or positrons can process those photons.

We still face Heisenberg uncertainty as a limit on how quickly these photonic memories can be recalled. The product of the measured time of arrival of a photon and its measured energy (and thus the number of distinguishable frequencies) has a fixed uncertainty -- if we measure the time with greater precision, we can distinguish fewer frequencies, and vice versa. This sets a finite limit on the rate at which we can process the information stored in the photons. Seth Lloyd has calculated that 1 kilogram of mass converted into energy can perform at most 10^50 operations per second. So future civilizations could only stave off Malthus by going photonic -- Malthus will still eventually catch up, assuming Darwinian competition in reproduction remains.

In addition to classical bits stored as photon frequencies, an exponentially higher number of quantum bits (qubits) might be stored in the entangled states of these photons. However, to use some number of these qubits requires destroying an exponentially larger amount of them. Thus, against exponential population growth memory storage itself remains cheap, but recalling memories or thinking about things becomes exponentially expensive. Qubit minds might stave off Malthus by hibernating for exponentially longer periods of time, waking up only to observe an exponentially decreasing number of interesting events.

My argument that we may figure out how to crack three-quark particles like neutrons and protons into photons relies on the probability, due to the imbalance of protons and anti-protons (and neutrons and anti-neutrons) in the observable universe, that baryon number (a property of quarks) is not necessarily conserved, and is falsifiable in that sense: if for example we discover with better telescopes that the amount of antimatter in the universe is the same as the amount of matter, that will at least strongly suggest that even at Big Bang energies baryon number is conserved, rendering the possibility of ever converting the quarks which constitute most of the mass of neutrons and protons into non-quarkish things (like electrons, positrons or photons) extremely unlikely. It's also somewhat imminently testable insofar as if LHC and similar colliders continue to fail to crack the proton, that further dims prospects. Feasibility, however, is not so testable: one could argue that, even if baryon number was not conserved in the Big Bang, and even if we soon discover how to crack the proton in high-energy colliders, we may never figure out a method, analogous to catalysis in chemical reactions, to crack protons at economically low energies or to productively recycle the energies used to perform the conversions rather than it being dispersed as waste heat.

(h/t: the phrase "Cosmic Malthus" to describe Hanson's theory is from commenter Norman at Robin's blog).

Posted by Nick Szabo at 1:41 PM

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4 comments:

newt0311 said...

Wow, it amazes me how consistently meta-physicists continue to ignore historical evidence and assume (implicitly to be sure) that they are different from the past.

It is very easy to tell how probable Hanson's theory is. We collect up the major Malthusian predictions in the past and consider how many of them worked out. Answer: almost none. Therefore, the chances of this one being important are similarly low to nil (assuming that we are going by logico-experimental reasoning here).

10:32 AM

nick said...

Malthusian effects were entirely normal before the agricultural revolution that accompanied the industrial revolution in Britain, and in the 3rd World before the Green Revolution in the latter half of the 20th century. (A big h/t to Norman Borlaug who recently passed, and to my dad who also worked on the Green Revolution). Hanson and Sandberg are convincing that for current growth rates in use of materials to continue exponentially for 10,000 years there has to be vastly (far more than the mere improvement from atoms to photons I'm talking about here) more room at the bottom, or no limits on velocity at the top -- both of which violate currently known physics.

Of course, one of my points here is that predicting the future of resources is not so simple as counting things (whether it's barrels of known oil, in a previous post, or even something seemingly so basic as atoms when were are talking about the distant future).

Other arguments (material use may or may not become an exponentially small proportion of the value of our economy, Darwinian reproduction pressures may or may not be indefinitely overcome, etc.) are needed to address the question of whether per capital economic growth (i.e. value per capita) can continue indefinitely.

12:00 PM

newt0311 said...

@nick

Malthusian effects were entirely normal before the agricultural revolution ... worked on the Green Revolution).

I was not well aware of that fact. If Malthusian were normal then, they become normal again.

However, I do not think Hnason's reasoning carrier much value as physics has a tendency of being re-written about every century in previously unforeseen ways and I have yet to see a detailed prediction about the human environment* farther than a few decades and based on some systematic theoretical basis that has been proven correct (or am I wrong here as well?).

* By "human environment", I mean the world that humans will be living in. I.e., the knowledge of physics, economic advancements, or temperature of the air. This is in contrast to humans themselves who have been predicted by quite a few people over times as large as two centuries. Here would be Tocqueville's or Carlyle's analysis of American democracy, or over a shorted period, Burnham's prediction of massively increased crime.

8:43 AM

Anonymous said...

Don't worry. The Big Bang will come around again. Even if it doesn't, we won't be around for the heat-death, so let's live it up now.

6:58 AM

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